Examining barriers in technology-enhanced problem-based learning: Using a performance support systems approach

Sung Hee Park and Peggy A. Ertmer

Sung Hee Park is a full-time lecturer in the Department of Educational Technology at Ewha Womans University. Her research focuses on problem-based learning, technology integration and effectiveness of e-learning. Peggy A. Ertmer is a professor of Educational Technology at Purdue University. Her primary research interests relate to case- and problem-based learning, technology integration, and feedback in online learning environments. She currently serves as the co-editor of a new online journal, The Interdisciplinary Journal of Problem-Based Learning. Address for correspondence: Sung Hee Park, Department of Educational Technology, College of Education, Ewha Womans University, Seoul, Korea, 120-750. Email: sungheepark@ewha.ac.kr. Peggy A. Ertmer, Purdue University, College of Education, BRNG Room 3144, 100 N. University Street, West Lafayette, IN 47907-2098. Email: pertmer@purdue.edu

Abstract
This study focused on the barriers that middle school teachers faced when implementing technology-enhanced problem-based learning (PBL) in their classrooms. Using a human performance-based model, we interviewed teachers, administrators, university faculty and technical support staff to determine the perceived importance of multiple barriers to the implementation of technology-enhanced PBL. Twenty-one teachers, two school administrators and a project manager, two faculty members, and two technical support staff participated in the study. Interview data were supported by surveys, classroom observations and researchers’ reflective journals. Results suggested that lack of a clear, shared vision was the primary barrier. Additional barriers included lack of knowledge and skills, unclear expectations and insufficient feedback. Recommendations to support teachers’ efforts to integrate technology-enhanced problem-based learning are presented.

Introduction
Although computers and technology are prevalent throughout our society, teachers have yet to incorporate technology into regular instructional practices (Cuban, 2001). From Cuban’s perspective, teachers don’t understand how technology can be integrated, and school systems have not been restructured to fully support integration. Becker (1994) noted that meaningful technology use tends to align with constructivist teaching methods, thus, current professional development efforts are moving from an
emphasis on technical skills to a focus on facilitating student-centred pedagogy (Russell, Bebell, O’Dwyer & O’Connor, 2003).

Problem-based learning is a constructivist teaching method in which students learn content knowledge and problem-solving skills through investigating and solving ill-structured problems (Hmelo-Silver, 2004). Technology often plays an important role during the problem-based learning (PBL) process, serving as a critical tool for information searching, organising and analysing data, and presenting solutions. While technology is not a required component of PBL, both the inquiry process and the resulting solutions can be enhanced by its use, adding elements of authenticity and relevance to students’ work. For example, rather than introduce the driving question (or “problem”) through a text-based scenario, a video clip can be used to present interviews with key stakeholders. Students can collect relevant data or recent information using the Internet, and then analyse and manage the data and other supportive evidence using the same tools that professionals use: spreadsheets, digital pictures and video clips. Finally, students can develop and share their solutions with key stakeholders using presentation or video software. As a result, technology-enhanced PBL can provide meaningful learning experiences (Ertmer, Lehman, Park, Cramer & Grove, 2003; Jonassen, Howland, Moore & Marra, 2003), as well as a meaningful and effective way to integrate technology into the classroom (Sage, 2000).

While numerous studies have identified barriers teachers face during technology integration, little research, if any, has been done using a human performance systems approach. For example, Ertmer and her colleagues (Ertmer, Addison, Lane, Ross & Woods, 1999; Ertmer et al, 2003; Park & Ertmer, 2007) identified barriers related to planning for and implementing technology-enhanced PBL, such as lack of preparation time, limited resources, lack of administrative support and limited class time to implement PBL. Brush and Saye (2000) and Land (2000) described the difficulty teachers experience adjusting to their new roles as guides and helping students become self-directed. In this study, we looked beyond teacher barriers to examine barriers that existed across the school system. Using a holistic model, we sought to incorporate the perspectives of multiple stakeholders involved in a 5-year change effort.

Recently, Schaffer and Richardson (2004) and Wedman and Diggs (2001) used a human performance systems approach to address the development and resource requirements for technology integration in teacher education systems. In these studies, the researchers applied a performance pyramid model (Wedman & Graham, 2004) to identify the support factors needed by various stakeholders to integrate technology within the classroom (see Figure 1). The performance pyramid model lists six foundational factors for successful performance. When present, these factors can greatly impact the ability of individual performers and groups to successfully complete the given tasks. Factors impacting performance include:

- knowledge and skills—the training or know-how needed to complete the task;
- performance capacity—the physical or mental ability to do the task;
motivation and self-concept—the appropriate desire to complete the task in the manner required;
• tools and environment—resources and processes designed to help improve performance;
• expectations and feedback—understanding of what is to be done, as well as responses from project stakeholders upon completion of the task; and
• rewards, recognition and incentives—appropriate acknowledgment of successful completion of the task.

These six factors are all influenced by the overall culture of the impacted organisation. In addition to culture, the vision (mission, goals) of the organisation must be taken into
account, as well as any resources (workers, capital, time) that are available to those affected within the organisation.

Wedman and Diggs (2001) used the performance pyramid model to investigate factors affecting technology integration based on surveys and interviews with college faculty. Schaffer and Richardson (2004) extended the study by Wedman and Diggs to identify major barriers to technology use in the classroom by including, in addition to faculty members, students in the college of education, and cooperating teachers at area K-12 schools. However, neither study focused on performance differences between expert and typical stakeholders within the same context. This study addressed this gap by applying the performance pyramid in a middle school context to identify perceptions of barriers across different stakeholder groups, including both expert and typical performers.

More specifically, this study was designed to examine stakeholders’ perceptions of the barriers teachers encountered when planning for and implementing PBL in the middle school classroom using a human performance systems approach. The research questions were:

1. What are the differences in performance between expert and typical PBL teachers?
2. What are stakeholders’ perceptions of the barriers teachers encounter when planning and implementing PBL in the middle school classroom and what is their relative importance?

Methodology

Overview

We collected data from four sources to determine the gaps between expert and typical PBL teachers, and to identify and determine the relative importance of the barriers teachers encounter while implementing PBL. The data sources included a survey of teachers’ perceptions of the barriers encountered while planning for and implementing PBL, interviews with teachers and seven non-teachers (administrators, technical support staff and university faculty members), observations in four classrooms during PBL lessons, and the reflective journals of three researchers.

Setting and participants

The setting for this study was a medium-sized middle school in a small, rural community in the Midwest. As part of a grant-funded initiative aimed at supporting technology-enhanced PBL, all teachers at the school were required to implement at least one PBL unit during the academic school year. Two university faculty members and five graduate teaching assistants were available to help the teachers during planning and implementation. The university faculty members were specialists in PBL. Three of the five graduate assistants worked as a research team to collect data for this study.

The participants from the school included 21 teachers with a range of previous experiences with PBL, two technology support personnel, the project manager and two
administrators. The two university faculty members also participated in this study. Twenty-one teachers completed a short survey. We then interviewed eight teachers, as well as the seven non-teacher participants. We observed PBL sessions led by five of the eight teachers we interviewed.

Procedure
To answer our first research question—what are the differences in performance between expert and typical PBL teachers—we observed 13 class hours led by five teachers we labelled ‘expert’ or ‘typical’. Expert teachers were identified by three criteria: (1) conducted three to four previous PBL units; (2) attended at least one professional conference related to PBL; and (3) had been acknowledged by both school administrators (a superintendent, a principal and a project manager) and PBL-support faculty as exemplary. Teachers labelled ‘typical’ had developed and implemented a PBL unit at least once. However, they were not as familiar with PBL as those labelled ‘expert’. By observing and interviewing both expert and typical teachers, we were able to gain a broader understanding of the factors that were perceived to be critical to successful PBL implementation.

To guide our observations, we developed a checklist from a review of the literature and interviews with PBL experts to identify differences between expert and typical PBL teachers. The checklist was pilot tested, modified and reviewed by the PBL experts for this study (see Table 1). The finalised checklist included six categories related to implementing PBL: (1) pedagogical beliefs (student-centred learning); (2) technology use for higher-order thinking; (3) planning and organising techniques; (4) classroom management skills; (5) collaboration; and (6) professional development. We asked each teacher whom we observed to describe the type and amount of professional development in which they had engaged (eg, PBL workshop, presentation at a professional conference). Each observation was completed by two researchers, who then came to consensus on the traits and practices that were observed using the checklist.

To answer our second research question—what barriers do teachers encounter when planning and implementing PBL in the middle school classroom and what is their relative importance?—we used interviews with 15 stakeholders (eight teachers, two school administrators, one project manager, two technical support staff, two university PBL faculty members), a survey and our reflective journals. Interviews were conducted with a variety of stakeholders to examine the perceived barriers to implementing PBL from different viewpoints. Interview lasted around 50 minutes using a semi-structured questionnaire. Interviewees were asked about the current and ideal status of both the organisational support and the PBL practices of teachers.

We based the survey on Wedman and Graham’s (2004) performance pyramid, and used it to identify barriers teachers encountered during the PBL process. The pyramid included the factors noted above: knowledge and skills, capacity, motivation, environment and tools, expectations and feedback, and rewards and incentives. The survey included eight forced-choice questions and one open-ended question (see Table 2). For
Table 1: Observation checklist for PBL practices

<table>
<thead>
<tr>
<th>Required competencies</th>
<th>Best practices (measurable practices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogical beliefs:</td>
<td>• Encourage students to bring their own solutions (ie, avoid giving direct answers)</td>
</tr>
<tr>
<td>student-centred</td>
<td>• Form students into groups and assign different roles</td>
</tr>
<tr>
<td>learning</td>
<td>• Spend a minimal amount of time delivering content knowledge to students</td>
</tr>
<tr>
<td></td>
<td>• Use open-ended questions instead of yes/no questions (using how, when, where, what if ...)</td>
</tr>
<tr>
<td></td>
<td>• Have students self-evaluate and reflect on the problem-solving process (journaling, self-checking rubrics, etc)</td>
</tr>
<tr>
<td></td>
<td>• Promote cooperation and teamwork (form students into groups and assign different roles)</td>
</tr>
<tr>
<td>Technology use</td>
<td>• Integrate technology components in the process</td>
</tr>
<tr>
<td>for higher-order</td>
<td>• Use computer tools to convert data (eg, figures, facts) to meaningful knowledge (eg, use the data for final presentation)</td>
</tr>
<tr>
<td>thinking</td>
<td>• Provide a set of advanced techniques for using software or hardware (ie, how to use Boolean functions for better online search results, how to insert multimedia components in PowerPoint)</td>
</tr>
<tr>
<td>Planning and</td>
<td>• Provide support for higher-order thinking using technology (ie, provide criteria for evaluating websites)</td>
</tr>
<tr>
<td>organising</td>
<td>• Use ill-defined and real world problem as a driving question</td>
</tr>
<tr>
<td></td>
<td>• Well-organised PBL stages (problem formation, data collection, brainstorming solution, evaluating and selecting solutions)</td>
</tr>
<tr>
<td></td>
<td>• Refer to information on Indiana academic standards when planning</td>
</tr>
<tr>
<td></td>
<td>• Prepare and arrange various resources to help students gather information (guest speakers, video tapes, and library resources)</td>
</tr>
<tr>
<td></td>
<td>• Prepare performance-based evaluation methods</td>
</tr>
<tr>
<td></td>
<td>• Have self-monitoring guidelines (ie, checking overall schedule frequently)</td>
</tr>
</tbody>
</table>
the forced-choice questions, teachers were asked to indicate whether they agreed, disagreed or were unsure if certain supportive factors were present during their PBL efforts (eg, ‘Expert PBL support is available in a timely and helpful manner in our school’. ‘I have received explicit expectations regarding the implementation of problem-based learning [PBL] in my school’). For the open-ended question, teachers were asked to list any specific factors that they perceived as being personal barriers to PBL implementation.

After completing each observation, the researchers described in a reflective journal observed practices that may not have been captured by the observation checklist. These data were used to triangulate the other data sources. After analysing all the survey, interview and observational data, the researchers determined the relative weight of each barrier by considering all stakeholders’ opinions equally. After reaching consensus, we combined those relative weights to determine the final ranking among barriers.

**Results**

*What are the differences in performance between expert and typical PBL teachers?*

Analysis of the classroom observational data indicated noticeable differences between the performance of typical and expert PBL teachers on many of the best practices included on our checklist, especially on those practices that were important to the successful implementation of PBL. Some of the biggest differences between expert and


Two expert PBL teachers taught sixth grade language arts and had collaborated on developing and implementing PBL units for more than 5 years, while the three typical teachers worked individually on their PBL units. The expert teachers asked students to self-evaluate and reflect on the problem-solving process at the end of every PBL class, while one typical teacher used this process only once. In addition, the expert teachers provided self-monitoring guidelines, frequently checking students’ work, while none of the typical teachers did this.

Our second research question was designed to examine barriers that may have impacted the performances of expert and typical teachers. These results are discussed next.
What are stakeholders’ perceptions of the barriers teachers encounter when planning and implementing PBL in the middle school classroom and what is their relative importance?

Our analysis of the data from all stakeholders suggested that the perceived importance of the barriers was in this order: vision-sharing, feedback and expectations, knowledge and skills, motivation, rewards and incentives, and tools and environment. However, not all participants agreed about the relative importance. In the paragraphs that follow, we report the data that support the final ranking of barriers.

Vision sharing
Interview data suggested that disparate visions among stakeholders was a major barrier to the effective implementation of PBL in this study. Whereas administrators indicated that the overall purpose of technology-enhanced PBL was to increase student-centred learning through the use of technology, PBL support faculty believed that the goal was to promote pedagogical change through the implementation of a more student-centred approach to instruction (ie, PBL). In general, teachers were confused about the goals of the PBL initiative. When asked why the administration expected all teachers to implement PBL, one teacher said, ‘That’s where I have a little bit of a problem because I’m not sure what they are trying to accomplish’. Another teacher stated, ‘I think they are trying to be innovative and do things other schools aren’t’.

Feedback and expectations
On the survey, only five of the 21 teachers agreed that they received regular and helpful feedback on their implementation of PBL. Five out of eight teachers interviewed mentioned that they never received feedback on their implementations of PBL, while the other three mentioned receiving informal feedback from each other or parents/local community. One teacher asked, ‘Is there any formal evaluation or feedback?’ Another noted, ‘They haven’t really checked on us; I don’t really know how they would know if I did it’. However, the three administrators perceived this differently. While one mentioned there was no feedback for teachers, the other two noted that teachers used either a self-evaluation system or were provided feedback by the school administrator. Faculty members suggested the need for feedback from either school administrators or mentors such as the graduate assistants.

Knowledge and skills
On the survey, 15 teachers indicated that they had the knowledge and skills needed to effectively implement PBL in the classroom, while six indicated that they did not. Two teachers interviewed indicated that they lacked knowledge related to how to plan for and implement PBL in their classrooms. One teacher said, ‘I still don’t know what I’m doing or if I’m doing it right’. Another teacher explained, ‘A half day of workshop wasn’t enough time to develop or even understand [PBL]’. Two of the three school administrators and both faculty members agreed that teachers did not have enough knowledge or skills related to either technology or PBL.
Motivation
Fifteen of the 21 teachers indicated on the survey that they were motivated to implement PBL in their classes, while three disagreed and three were unsure. When asked in the interview what motivates them to implement PBL, four teachers indicated that it was the students’ engagement in PBL units. One of these teachers mentioned, ‘I like to watch them get excited about what they are doing’. However, one teacher noted that the only motivation that he had was that it was a requirement, explaining, ‘If my boss says to do it, I do it’. The school administrators and faculty members did not consider motivation to be a barrier for teachers.

Rewards and incentives
Nine teachers who completed the survey agreed that the school offered rewards and incentives for the implementation of PBL, while nine disagreed and three were unsure. Many teachers mentioned in the interviews that their reward was that students gained ownership in their learning and enjoyed learning more. One teacher explained, ‘What is neat is that at the end of these PBL units they usually have more questions than answers... all of a sudden the world is a much bigger place and PBL allows that to happen’. However, two teachers who were interviewed did not perceive that there were any rewards or incentives. When asked what rewards there were for implementing PBL, one said, ‘Nothing for me, except that it’s my job’. School administrators thought that teachers might consider students’ excitement as incentives, as well as the free laptops provided by the grant and access to district-supported professional development. However, two teachers interviewed did not see these as incentives.

Tools and environment
On the survey, teachers were asked to indicate their agreement with the statement: ‘The physical environment and tools (hardware, software, network, local and school library, field trip support etc) of my school make it easy for me to implement PBL’. Nineteen teachers agreed, while one disagreed and one was unsure. We asked the teachers in the interview sample what other resources and help they needed in implementing PBL. Some teachers wanted opportunities to team teach. Others stated that they could use more preparation time. One of faculty members also agreed that more time was needed for teachers to prepare their PBL units.

Discussion and recommendations
As noted earlier, the results of this study suggested that the biggest differences between the performances of typical and expert PBL teachers included collaborating with peers, engaging students in self-evaluation and reflection on the problem-solving process, and providing self-monitoring guidelines for students. Based on the literature, these practices are recommended to maximise the potential of PBL (Hmelo-Silver, 2004). Students also gain from being involved in interdisciplinary PBL units (Stepien, Gallagher & Workman, 1993), and need to be provided with tools to help them self-monitor (Brush & Saye, 2000). Because these practices were not yet part of the teaching approaches used by the typical PBL teachers, implementation may not have been effective, causing them to see little reason to adopt this method. Helping teachers develop activities and/or
tools that enable students to self-monitor and self-assess their work may engender greater feelings of success among new PBL users, and thus greater confidence to try other PBL units in the future. Furthermore, establishing partnerships with other PBL teachers may provide opportunities for reflecting on their practice and initiating changes based on peers’ suggestions.

Second, data from the stakeholders suggested that the following barriers were ranked, in order of importance, from shared vision, feedback and expectations, knowledge and skills, motivation, rewards and incentives, to tools and environment. A major finding of this study was the disparity and uncertainty about the vision for this specific effort. Specifically, faculty members emphasised teachers’ pedagogical change through the use of PBL, while school administrators emphasised teachers’ uses of technology. This led to confusion among the teachers regarding what they should accomplish. This also contributed to a weak support for the implementation of technology-enhanced PBL. Others have identified vision sharing as essential to technology integration and the implementation of new pedagogical techniques (Anderson & Dexter, 2000; Hunter, 2001; Jukes, 1996). ‘When the vision is not shared, teachers often view the plan as just another example of rhetoric rather than a substantive commitment to a plan’ (Jukes, 1996, p. 14).

Our study also indicated that the lack of feedback and expectations was a major barrier to the design and implementation of PBL units. Schaffer and Richardson (2004) also found that insufficient feedback, relative to expectations, was one of major barriers to technology integration in the K-12 classroom. That is, teachers need regular corrective feedback, especially when they implement new teaching methods (Scheeler, Ruhl & McAfee, 2004; Spencer & Logan, 2003). Perhaps if the teachers had collaborated more closely with their colleagues, this barrier could have been addressed. Additionally, if the decision to implement PBL had been more collaborative, as opposed to being top-down, the teachers in this study may have felt more ownership of the innovation, and thus may have invested more of their time and energy into understanding the basic expectations and requirements for success.

In this instance, the results of this study illustrated the importance of establishing a shared vision, detailing expectations and providing feedback to support teachers as they implement new teaching methods, such as technology-enhanced PBL. Moesby (2004) also noted that communication of the vision, criteria for success, and action plans have been neglected during the change process in organisations. If these are not made public and discussed openly among stakeholders, participants may not be motivated to work towards a shared goal.

Many schools focus on acquisition of technology (hardware and software) instead of sharing a vision of pedagogy or providing any feedback and expectation about teachers’ performances in implementing technology-enhanced PBL. Saye and Brush (2004) stressed the importance of assessing the status of education to see where computers fit instead of assessing the status of the technology field to see where education fits. It is
unreasonable to expect teachers’ performances to improve if they are confused about their roles and are unsure of what the administrators expect, and whether they were performing in line with expectations.

We recommend sharing the vision of technology-enhanced PBL with teachers (ie, school strategic plans) and providing increased opportunities for collaboration among teachers, such as the development of joint units, peer coaching and mentoring. Teachers should be encouraged to develop joint units with other teachers and thus receive ongoing feedback from each other. Collaboration with peers may be an effective way to deal with many of the barriers teachers encounter when implementing PBL.

While many studies have focused on teachers’ perspectives regarding barriers to technology-enhanced PBL, fewer studies have used a systems approach to consider how to involve all stakeholders to support teachers’ efforts. The framework used in this study may provide an effective evaluation tool for others who are examining barriers to the adoption and implementation of new curricular methods, including PBL and technology integration. Pedersen and Marek (2007) stressed that teachers are being pressured to integrate technology or use an innovation to meet an expectation rather than having a concrete purpose for its use. Based on the results of this study, it appears important for teachers to possess a deep understanding of the purpose of the innovation before being required to make more substantial changes in their practices.

Acknowledgements

We would like to express our gratitude to Jay Blackman, Monica (Eun-Hwa) Lee, Brian Belland and Krista Simons for their efforts on this research and for their thoughtful comments on an earlier version of this paper.

References


© 2008 The Authors. Journal compilation © 2008 British Educational Communications and Technology Agency.


© 2008 The Authors. Journal compilation © 2008 British Educational Communications and Technology Agency.